Increased resource efficiency in wastewater treatment as a result of process simulations

Resource efficiency is becoming increasingly attractive from both an economical and sustainable perspective. The developed process models help the mining industry to become more resource efficient, emitting less polluted water and recovering previously wasted metal ions.

Have you ever wondered where the steel in your cooking utensils come from? Or the gold in your earrings? Or where the metal components that are required for your TV to work originates?

The answer to any of these questions is most likely that the metal originates from some sort of mining process. Mining processes are known to require a lot of resources. They are associated with a great power consumption as well as with very large flows of water during the leaching of the metals and minerals. In 2015, Sweden Statistics approximated that the Swedish mining industry used 815 Mm^3 of water in its annual production[1]. Leachate (mining process water), contains a number of different components that have been released during the leaching process that are dissolved in water. Two of the main components in leachate are sulfate and dissolved metal ions.

In this thesis project[2], a process model combining sulfate removal from leachate with metal ion recovery, was developed. The sulfate in the leachate is reduced to hydrogen sulfide by sulfate reducing bacteria in an anaerobic up-flow sludge blanket (UASB) reactor. The hydrogen sulfide is then removed from the bioreactor and transferred into three reaction vessels, where it reacts with metal ions to form metal sulfides. The metal sulfides are then removed using a sedimentation based technique called clarification.

Process simulations are a powerful tool in developing more resource efficient processes and so there were two process models developed to simulate the wastewater treatment process. The model created in the simulation software SuperPro, contains all of the unit operations of the process and can be seen as a fully functioning process model. This model, could easily be used to help size the process equipment, understand the magnitude of the streams or easily locate where in the process substances are present.

Whereas the second model, the Matlab model, functions as a "black box" model and only considers the in- and outflow if the overall process. This model contains the differential equations and necessary reaction kinetic equations that describe the process. The Matlab model is a great asset when one needs to understand the reaction kinetics (how, what and when a reaction occurs) and to understand how one part of the process will influence the results of other parts of the process.

The models would be fairly easy to adapt to a changed process flow, if for example another process than metal recover would be of interest it is fairly easy to switch out this part of the model. These models could be a first step in implementing a similar process or performing simulation based experiments ahead of real time experiments. They could also be used to predict the size of the process treatment plant, the amount of substrate that is necessary and how much time each of the processes will take.

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[1] SCB. (2017A). *Industrins vattenutsläpp, 1000-tal kubikmeter efter typ av recipient och år, oregelb*. Retrieved 10 21, 2018, from http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__MI__MI0902__MI0902F/UtslappVatten/table/tableViewLayout1/?rxid=f45f90b6-7345-4877-ba25-9b43e6c6e299#

[2] Modelling of a sulfate reducing and metal recovery process, within applications for treatment of industrial wastewaters, Kristina Broberg (2019).